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Studying of stowage massifs formation conditions in deep-laying rich KMA iron oxides developing and efficient stowage composition projection

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Abstract- On the example of Yakovlevsky iron-ore field which is characterized by composite hydro-geological and mining development conditions the natural monitoring technique of intense stowage massif strained state, which is formed in the descending layered dredging system of unstable rich iron oxides is proved and approved. Methods and equipment for carrying out measurements under trying conditions of underground operation are explained. The applied stowage massif formation technologies are characterized. The developed stowage compositions on the basis of ground domain granulouse slag and technological wastage with compressing strength of 11.4 MPas are presented (megapascal MPa) .
Keywords: rich iron oxides; stowage massif; deformations; durability; technological wastage; stowage compositions, super-softener

1. Introduction

The Yakovlevsky iron-ore field is developed by underground way at a depth over 600 m, thus the developed ore body over the undrained system high-head (4.0 MPas) water bearing horizons remains.

Need for rich iron oxides dredging with preservation of the natural hydro-geological mode in the above-lying water bearing horizons, decrease in losses and impoverishment formed the basis of system use with the developed space laying [1]. It gave the chance to minimize waterproof layers shifts, to prevent water conductive cracks formation and to put aside system of water bearing horizons drainage.

One of the main problems, connected with Yakovlevsky and similar fields of the Belgorod iron-ore region of Kursk Magnetic Anomaly (KMA) development (Kursk Magnetic Anomaly), is geomechanical providing of the applied systems development in the composite mining and hydro-geological conditions of the region. The methods of stowage massif formation conditions study and traditional schemes of obtaining information on its stressed state applied on Yakovlevsky mine have a number of serious shortcomings: labor input of experienced works combination to rigid production cycle of clearing, dredging of iron oxides and their applicability can only be performed on restricted sites [2]. There are such important unresolved questions as obtaining operational data on intense strained state of simulated massif at various clearing works options taking into account the actual strength and straining characteristics, course features of hardening stowage massif thermal conditions, as well as consumption decrease of expensive cement stowage works and replacement of natural filler (sand) with a technological wastage for significant improvement of the KMA region ecological environment.

2. Data and Methods.

In stowage compositions the following materials were used:

– wet magnetic separation wastage enrichment of JSC Kmaruda Combine ferruterous quartzites;

– ground domain granulouse slag of PJSC Tulachermet 3rd sort;

– ground processing waste of dolomite and calcareous crushed stone;

– super-softener of Poliplast SP-1.

The chemical analysis of materials made by X-ray fluorescent analysis (XRF) method on ARL Optim'X spectrometer is given in table 1.

Table 1 – Element structure of technological wastage in recalculation on oxides

Connection	Blast furnace slag	Enrichment wastage	Dolomite processing waste	Waste products of calcareous crushed stone
	contents, % by wt.			
1	2	3	4	6
CaO	46.6	8.45	82.96	96.15
SiO_2	42.52	61.38	3.73	0.815
Al_2O_3	3.12	0.978	1.15	0.092
MgO	2.42	2.86	9.06	0.398
Fe_2O_3	1.55	23.55	1.58	1.5
K_2O	1.4	1.1	0.619	0.0391
SO_3	1.03	0.101	0.0544	0.0371
P_2O_5	0.481	0.646	0.492	0.332
TiO_2	0.294	0.242	0.062	-
Na_2O	0.27	0.4	-	0.37
BaO	0.166	-	-	-
MnO	0.079	0.243	0.0613	0.0848
CuO	0.0323	-	0.034	0.0199
WO_3	0.0257	-	0.0403	0.023
SrO	-	-	0.0921	0.133
other	0.012	0.05	0.0646	0.0061

Super-softener SP-1 Poliplast (super-plasticiser Polyplast SP-1) represents organic synthetic matter on the basis of naphthalene monosulphonic acid and formaldehyde condensation product with a specific ratio of fractions with various average molecular mass − polinophthalynmetylensyphonite or metylenbis (naphthalynesulphonate) sodium.

Average particle size of components defined by laser diffraction analyzer of particle size "Analysette 22 NanoTec". Measurement was taken by dispersion of powders in liquid by means of ultrasound.

Compressing strength of stowage composition exemplars was defined with use of electronic testing machine Instron 5882.

For simulated stowage massif formation monitoring the design of observing strain-measuring stations which are established in excavation before its filling with stowage mix is offered and approved. Parts of complex observing station are: string converters of linear deformations from the lengthiest gaged base of 400 mm (string converter of linear deformations (string converter of linear deformations PLDS-400)) designed by Gidroproyekt for monitoring of deformations in three mutually perpendicular directions (X, Y, Z), the string strain gage for the characteristic temperature shrinkage strains accounting, PTS-60 temperature sensing device (temperature string converter (string converter of temperature PTS-60)) and the device for measurement of reservoir crest part mountain pressure of excavation (fig. 1).

3. Results and Discussion

Gaging stations installation in clearing developments is made, starting from the top-most developed layer. It allows to control intense strained state change of the stowage massif when carrying out point development and at its side job underlying clearing layers when the stowage massif acts as a simulated roof. For the temperature and moist deformations accounting the method of cone (shrinkable cylinder) frustum applying the put development of unintense exemplar bound to the concrete massif on the area of one of the end faces is used. The complex technique allows to conduct temperature schedule research, PTS-60 string temperature sensing devices are used for this purpose.

Using the deformations measured in each of three directions, it is possible to analyze stowage massif intense strained state change in zones of clearing dredging influence [2].

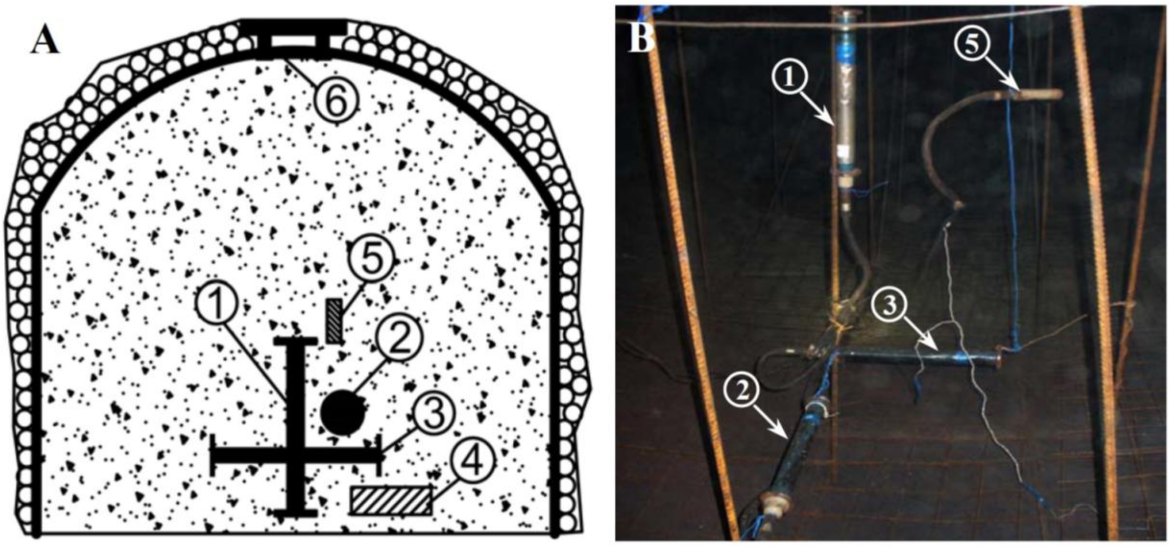

Fig. 1. Observing station: a – scheme of elements; b – placement in development (deformometre: 1 – vertical, 2 – axial, 3 – transversal; 4 – shrinkable, 5 – a temperature sensing device, 6 – the registrar of pressure)

Results of the stowage massif statistical tests processing around the established stations showed that the confidence interval of stowage material average durability with reliability of 95% makes 7.1□0.2 MPa. The analysis of created stowage massif intense strained state specifies that the test tensions, which do not exceed 65% of the admissible actual backing resistance value to axial compression. The side job of the simulated massif clearing split of an underlying layer promotes vertical pulling stresses emergence, which in certain cases can exceed the admissible value of concrete resistance to axial stretching. However due to vertical reinforcing of stowage massif wholeness violations in observation places is not revealed.

According to the project the simulated stowage massif is formed as follows: the ore massif is developed by parallel split with fastening metal arch support. After completion of rich iron oxides dredging it is possible to carry out stowage works with minimum time lag. At first reinforcing of the lower (bearing) development layer by welded grid with cell size of 100×100 from wire of Ø 5-6 mm in combination with vertical fittings of Ø 12-14 mm is made, then two embedding stages follow. In the beginning the development sublayer on height of 2.5 m with normative durability of 10 MPas (only the first developed coat 4.5 m high) is put, after setting and sublayer contraction is carried out having added support of upper low-strong backing with normative durability of 1 MPa. Normative durability of backing on all underlying clearing layers under the protective sealing makes 4 MPas (over interfaces of underlying layers – 6 MPas), thus the "facilitated" arming schemes are used on stowage massif.

The actual compositions of stowage mixes are characterized by larger consumption of cement (150-400 kg/m^3) and natural filler (sand).

The component structure analysis of the world and domestic mines hardening laying showed that today cement, plaster, metallurgical slags [3-7], ashes of power plants [8-9], micro-silicon dioxide [10], and as inert filler – sand, dead rock, coal wastage, gravel, tails of enrichment are used as the most widespread type of cementing material [11-12].

Nevertheless, stowage composites on the basis of acid domain granulouse slag in combination with carbonaceous wastage and wastage of wet magnetic separation enrichment represent scientific and practical interest.

By crushed stone production the significant amount of grit-stones which on grain structure represent coarse sand is formed of limestone. These grit-stones are partially used in road construction, and in agriculture. But the main part of grit-stones is stored in dumps. The similar situation is characterized by production of dolomite when during its production and primary processing waste products make up to 30% of its production. At the same time dolomite and limestone are used for adhesive production. Therefore carbonaceous wastage introduction to stowage compositions significantly saves expense adhesives and promotes region ecological environment improvement.

In the first developed mixture the adhesives mix from domain granulouse slag and processing waste of dolomite ground separately to average particle size of 31.87 microns and 35.18 respectively.

In second composition adhesives mix from the domain granulouse slag and calcareous crushed stone waste products crushed separately in ball laboratory grinder to average particle size of 31.87 microns and 6.07 microns respectively.

As filler an enrichment wastage with average particle size of 29.71 microns was used, its surface is characterized by much higher maintenance of the active sites including for mechanical strengthened composites, than that of natural quartz sand which is traditionally used as part of stowage mixes [13].

For transportation suitable consistence preservation a bathotonic additive in the Poliplast SP-1 is added to water.

Mixes had the homogeneous pasty consistence and were not stratified at rest, thus they became well spread, which has important value when filling waste chambers.

In pasty stowage material minimum quantity water contains is necessary for ensuring its transportability. It promotes reduction of raised expense adhesives and simulated massif durability increase. Use of the pasty hardening mixes prevents break possibility in excavations of mud-laiden water from developed site. Potential advantages of pasty backing were noted by other researchers as well [4-7,10].

The original gross mixture composition and mechanical strength test data of the exemplars prepared by reference technique from these mixes are given in table 2, 3 respectively.

Table 2 − Gross structure of stowage composition

Expense of components (masses. %) at manufacture of stowage composition						
No.	Ground domain slag	Enrichment wastage	Ground processing waste		Poliplast WO-1	Water
			dolomite	limestone		
1	12	57.89	10	-	0.06	20.05
2	12	57.89	-	10	0.06	20.05

Table 3 − Test data of stowage compositions

No.	Cone sagging, mm	Compressing strength, MPa, aged		Density of mix, kg/m^3	Volume of salvage, masses. % for nonvolatile solid
		28 days	90 days		
1	135	5.36	7.8	2070	99.86
2	135	7.8	11.4	2050	99.86

It should be noted that the high durability of the second composition exemplars is explained by raised contents in formulation particles constituents less than 1 micron (over 18% by weight).

The subtlety of refinement components in the developed structures corresponds to degree of the cement grinding production and does not need a padding metabolic cost. The exception is waste products of calcareous crushed stone. Their hyperfine refinement in a ball grinder did not exceed time spent for refinement of other materials.

Taking into consideration that it is necessary to get brick minerals for cement production, with all that it implies of ecological disruption, advantages of the developed compositions are obvious.

4. Summary

On the basis of the experimental results presented in article it is possible to draw the following conclusions:

1. The developed technique of stowage massif intense strained state monitoring, which is formed at the descending layered order of working off, can be used at justification of the efficient geotechnologies providing safe conducting mining operations in depths over 600 m in the composite hydro-geological and mining conditions of the KMA region.

2. Pasty stowage compositions on the basis of ground technological wastage provide high processing behavior of stowage mixes − mobility and durability.

3. Use of the developed stowage compositions completely excludes consumption of cement and natural fillers, and also allows to increase volumes of the utilized technological wastage. It promotes complex use of mineral raw materials and environment protection against consequences of anthropogenic influence.

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